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radars and flying saucers

METEOROLOGICAL DEVELOPMENT LABORATORY (CRL)

Since the early days of radar, targets have appeared on radar screens that weren't targets at all. These false targets are known as angels, and they have given credence to many flying saucer reports.

The cause of these false targets has never been fully understood, although it has been known for some time that a part of the explanation is found in sharp discontinuities in temperature and moisture content in the atmosphere. It was assumed until fairly recently that the false targets represented nothing more than the backscattering of energy from these inhomogeneities of the atmosphere. But since these inhomogeneities produced false targets only at close range some further explanation was needed.

P. J. Harney of AFCRL, after analyzing results of many observations made by the Weather Bureau, WADC and AFCRL, has suggested a model of the mechanism of false radar targets. Conditions necessary for creating these false targets are typically found in the Kansas region. On certain hot days in mid-summer without a single cloud in the sky, the radar scope may be cluttered with these targets. The pattern of this clutter, it was found, is quite similar to the distribution of certain types of cloud populations found in Florida. This cloud pattern grows out of a condition known as Benard cell circulation. It was suggested that this kind of circulation was present in the Kansas observations, even though no clouds were present.

Benard cell circulations result in concave, dish-like reflecting surfaces at altitudes up to about 6000 feet. The radar beam reflects from this surface to the ground, and retraces its path to the radar giving rise to a false target. We can conceive of a number of these reflecting dishes set in a huge undulating layer with the various dishes (or dimples) set in the layer, presenting slowly changing aspects to the radar.

Under certain conditions, it is possible for a low angle radar beam to be reflected from one surface to another before retracing its path to the radar. Some of the false targets that are observed are caused by this mechanism, according to the model suggested by Mr. Harney. Because of the undulating nature of the reflecting surface, the target will thus appear to move rapidly, giving rise to flying saucers being reported on radar screens.

This model also serves as an explanation of occasional transmissions over great distances of VHF and UHF signals.

TO OUR READERS

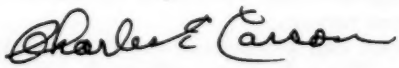
The continuing goal of the "OAR RESEARCH REVIEW" is an attempt to satisfy the information needs of both the scientist and the nonscientist decision maker, since we feel each is of importance.

It is inevitable that many decisions concerning basic research, from the budget that supports it to the manner in which it is fed into applied research and development activities, are made by people who are not scientists.

We believe that it is imperative that these people be informed about research in progress, and understand something of its potentialities. It is equally imperative that the scientist be kept up-to-date on research projects occurring within his areas of interest. Each time this publication prevents needless duplication of effort by informing a research scientist of new knowledge discovered, it will have achieved an important contribution to the conservation of the Free World's scientific resources.

Those of you among our readers who feel a need for further information about a topic covered in any issue are urged to contact the author or originating laboratory direct. Addresses for use on such occasions are shown on inside back cover of this issue.

Constructive criticism and suggestions for improvement will be most welcome, and should be directed to this headquarters, ATTN: RREI.



CHARLES E. CARSON
Colonel, USAF
Deputy Commander

Biological pattern recognition

DR. HARVEY E. SAVELY, LIFE SCIENCES DIRECTORATE , (AFOSR)

In spite of years of study of vision we know little about the principles of image perception. We do not know how the visual pigments in the retina initiate the nerve impulse; we do not know what transformations are made by the network of nerve cells associated with the retina, nor the further transforms carried out on the messages reaching the brain. In short, we do not know how animals recognize and perceive form. This is the heart of the problem of pattern recognition upon which so much engineering effort is being expended, and which is crucial to the new classes of automata that we are striving for.

It is intriguing to consider the success that nature has had in devising numerous solutions to this problem, and apparently by means of independent inventions -- for example, the camera eye of spiders, mollusks, and vertebrates, and the compound eyes in several classes of arthropods.

The Air Force Office of Scientific Research has sought to support biological studies that promise to increase our knowledge of the biological principles involved. An important new insight into the visual mechanism in vertebrates was made by Lettvin and Maturana in studies of the frog (Maturana with an AFOSR grant in Chile and at MIT). This study was previously reported in this bulletin. (See also IRE Prodeedings, Nov 1959.) Lettvin and Maturana are now engaged in similar studies on the octopus (also previously reported). Hubel, an AFOSR grantee, is making observations on the kinds of interaction resulting in the monkey's brain, from various kinds of patterned visual stimuli. In invertebrates, the original studies on beetle vision by Reichart and Hassenstein (AFOSR grant, Tubingen) are being repeated and expanded by Bliss at Stanford Research Institute. Vowles, at Oxford, is conducting similar studies of the neurophysiology of vision in insects. The vision of spiders is now being investigated by Moruzzi, University of Pisa. In all of these studies and others that AFOSR supports, the aim is to discover how nature has designed a mechanism that perceives pattern. Viewed in this light, as an attempt to grasp principles by studying an object already invented, it would seem to have great appeal to engineers. If the "object" had been invented by the Russians, we could be sure that there would be a rush to find out how it works. Perhaps our imagination has been dulled by our superficial familiarity with so many biological objects. But it must be admitted that up until

recently, the tools and concepts of biology that could be applied effectively to these problems did not offer too much encouragement.

Biologists are still enough impressed by the difficulties involved not to make promises of early "breakthroughs", but their techniques are progressing so rapidly that we can foresee that some of the mystery that surrounds vision should clear up before many years.

Is there a universal law of information handling employed by nature in all these cases, or are there several ways the problem can be solved? Students of automata would like very much to know.

DISTINGUISHING UNDERGROUND NUCLEAR EXPLOSIONS FROM NATURAL EARTHQUAKES

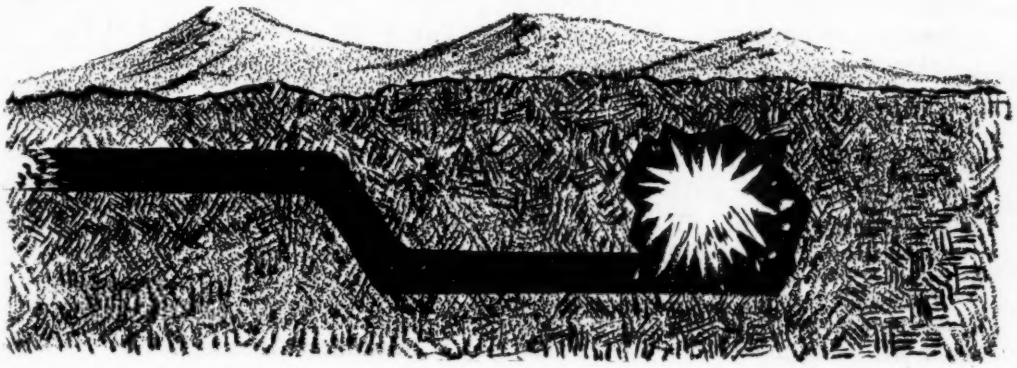
HOWARD W. LEAF, CAPTAIN, GEOPHYSICS DIVISION (AFOSR)

A better understanding of the mechanism of earthquakes is expected as the result of new techniques being developed at the Seismological Laboratory of the California Institute of Technology. This work is part of the Air Force Office of Scientific Research basic research program that is supporting the Advanced Research Projects Agency's Vela-Uniform program. The Vela-Uniform program has as its objective the development of, at the earliest possible date, a system for distinguishing underground nuclear explosions.

Earthquakes result from the sudden shearing of rocks that takes place after a gradual building of strain caused by the continuous slow movement of the land mass on one side of a fault in relation to that on the other side. The methods developed make it possible to determine the length of fault movement, as well as the direction and velocity during a great earthquake. Geophysicists, Ari Ben-Menahem and M. Nafi Toksoz, under the supervision of Dr. Frank Press, the Laboratory Director, using new computer analysis techniques on data from the great Mongolian earthquake of 1957 have found that the shearing action started at one point and moved at a rate of about 7,000 miles an hour along a southeasterly line, 340 miles in length. This new and promising technique involves analyzing the surface waves that radiate from the earthquakes and travel completely around the earth in about two and three quarter hours. Using one set of surface waves that traveled 6,000 miles directly to Pasadena and another set that traveled the long way around -- 18,000 miles -- and comparing their

energy spectra on the Cal Tech Jet Propulsion Laboratory IBM Computer, the length of fault activity, and the direction and velocity of the break was derived. The technique is based on a Doppler-effect concept which supposes that the energy in the direction of the break is greater than that in other direction, and thus putting more energy in the direction of the motion.

By using data from more than one station it is believed that the method will be applicable to earthquakes of small magnitude. The next step in the development of this program is to try and find a way of determining the depth of the fault activity. Development of these last two aspects of the problem will provide a significant contribution to the distinguishing of underground nuclear explosions from natural earthquakes.



REVISED STANDARD ATMOSPHERE

METEOROLOGICAL DEVELOPMENT LABORATORY (CRL)

U. S. scientific and engineering organizations whose research and operational activities extend into the upper atmosphere and near space will soon adopt a new standard atmosphere. The standard atmosphere is an atmospheric profile of temperatures, densities and pressures from ground level outward to 700 km.

The standard atmosphere will provide scientists and engineers with a set of constants for use in calculating the speed of sound at any given altitude, mean free path and the trajectories of missiles and the orbits of satellites.

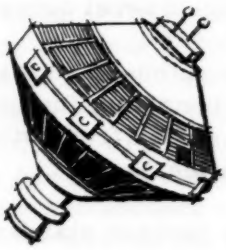
The revised standard atmosphere study was carried out under the

joint sponsorship of AFCRL, NASA and the U.S. Weather Bureau. Contributing to the work was an unofficial group of 29 scientific and engineering organizations making up the U.S. Committee on the Extension of the Standard Atmosphere (COESA). COESA was formed in 1953, and published its first standard atmosphere in 1958.

Since that time, hundreds of rockets and satellites have sampled various components of the atmosphere at varying altitudes, and knowledge of the upper atmosphere has been considerably refined. The earlier study, for example, established the temperature at 300 km at about 1000 degrees K. In the revised standards, the temperature at that altitutde is 1500 degrees. The previous standards considered the atmosphere only out to 300 km; the revised standard extends out to 700 km. Up to about 100 km, the revised standard atmosphere is in rough agreement with the previous profile. Beyond 100 km, there is a marked departure. The new standards show that beyond 400 km kinetic temperatures become isotopic at about 1400 degrees K.

The revised U.S. Standard Atmosphere depicts typical mid-latitude year-round conditions averaged for daylight hours and for the range of solar activity that occurs between sunspot minimum and sunspot maximum. COESA is also developing a set of supplemental atmospheres which will represent mean summer and winter conditions by 15 degree latitude intervals from the tropics to the poles to an altitude of 90 km. These atmospheres will appear sometime later as an appendix to the revised U.S. Standard Atmosphere.

Standard atmospheres have been formulated by other groups in addition to COESA. The most important of these are the standard atmospheres of the International Civil Aviation Organization (ICAO) and the Committee on Space Research (COSPAR) International Reference Atmosphere. The COESA's standard atmosphere is in close agreement with those of the other groups. The lower 20 km of the COESA atmosphere coincides precisely with that of ICAO. COESA has recommended to ICAO that the lower 32 km of its representation of the atmosphere be adapted for international standardization.



EARLY DETECTION of DISEASED LARYNXES

COMMUNICATION SCIENCES LABORATORY (CRL)

Detection of cancer in the larynx at an early stage is possible by analyzing human speech signals. A study recently completed by Lt. Phillip Lieberman of AFCRL on a sample of 32 speakers with known pathological disorders associated with the larynx showed that diagnosis can be made with a high degree of reliability.

The study involved an analysis of the waveforms of human speech by computer -- specifically the waveform concerned with the pitch component of speech. The possible use of pitch perturbations as a diagnostic tool for pathologic disorders is a by-product of AFCRL's speech research program.

The goal of this speech research program is to develop methods for transmitting voice messages over extremely narrow frequency bandwidths. Pitch studies are an important part of this AFCRL program because pitch lends to speech much of its emotional content. A requisite for speech research is the understanding of the mechanism of the speech organs.

Three things are involved in pitch generation -- the vocal cords, the variation of air pressure within the vocal tract and muscular tension. The vocal cords consist of two relatively low mass membranes. Their movements establish the pitch periodicity of the acoustic speech waveform. These movements are regulated by the air pressure against the vocal cords and by muscular tension. Even with normal speakers, variations in pitch periodicity occur because of small transients in air pressure. However, growths or small polyps on or near the vocal cords alter the relative mass of the cords and create an imbalance between the two vocal cord elements. The system's mechanical damping factor is reduced and air pressure transients result in larger and more prolonged variations in pitch periodicity than is the case for normal speakers.

This knowledge of the operation of the vocal cords together with the known structure of the pitch waveform of normal speech led Lt. Lieberman to suggest waveform analysis as a possible diagnostic tool

for pathologic disorders of the larynx. To test this possibility, he secured the cooperation of Dr. Ralph M. Caulk of the Washington Hospital Center, Washington, DC, who provided taped voices of 32 speakers, whose ages ranged from 24 to 71 years, each with diseased larynxes.

The processing of the waveforms involves several operations. First they are displayed on an oscilloscope where they are photographed with an oscillographic record camera at 1,200 inches a minute. The processed 35 mm film is then read on a digital data reduction system, and the duration of each pitch period is measured and automatically punched on IBM cards. These cards are processed on a 7090 computer.

A normalized integral (0.5 msec or greater) of all pitch pertubations is established for each speaker and plotted. The plots, even for speakers with relatively small masses on or near the vocal cords, showed a marked departure from the plots of normal controls.

As a diagnostic tool, it is envisioned that taped recordings of a speaker suspected of having a diseased larynx could be sent to a central processing center, where the analysis of the waveform would be made. The analysis could be made with a specialized apparatus, obviating the need for a large general purpose computer. Cost of the waveform analysis could be reduced to less than a dollar for each examination.

HYPERSONIC wind tunnel models

HYPERSONIC RESEARCH LABORATORY (ARL)

When one thinks of wind tunnel models, he often associates them with scaled-down engineering models of aircraft or missiles. At the Aeronautical Research Laboratories, however, wind tunnel models take the form of fundamental shapes such as cones, cylinders, wedges, or spheres. These basic model shapes are used by the ARL scientists in their hypersonic wind tunnel facilities to carry out experimental portions of fundamental research programs in the field of hypersonic gas dynamics. Measured or calculated quantities such as the amount of heat transferred to a basic shape or the pressure and force distribution on a simple geometric body permit the basic behaviour of gases at ultra-high velocities (presently up to Mach 16) to be determined.

Although the ARL wind tunnel models are simple in shape, their instrumentation and construction frequently present formidable design

and fabrication problems. For example, experiments presently being performed by Lieutenants John Anderson and William Reinecke in the 3-inch hypersonic wind tunnel to determine pressure and temperature effects require sharp-nosed conical models (which resemble short, sharpened pencils) constructed of heat-resisting stainless steels. These models are placed at various attitude positions in the heated hypersonic air flow field and can be remotely changed in pitch (nose-up or nose-down) position. Two separate models are used, one a pressure model and the other a heat-transfer model. In the case of the pressure model, small stainless steel tubing is used to sense the pressure at numerous positions on the surface of the model. In the case of the heat-transfer model, temperatures are measured at various locations using very small thermocouples.

To accurately sense the pressures, a bundle of small tubing is brought into the hollow model from the rear or base of the model. These tubes are of the diameter of hypodermic needles and are threaded through accurately drilled holes in the sides of the model where they are welded in place. As many as a dozen of these pressure orifices can be built into a sharp cone model of pencil size. At this stage of construction, the model resembles a porcupine. The protruding excess tubing ("porcupine quills") must be removed by machining. The surface of the model must then be ground and polished to a finish resembling glass, while maintaining an extremely sharp point on the cone that cannot be touched without bending.

The temperature model is constructed by welding hair-like thermocouple wires to the inside of the hollow cone model. It has a uniformly thin wall thickness and is identical in outside dimensions and finish to the pressure model. These thermocouples are welded at precise locations using a very sensitive electrical resistance welder especially built for instrumentation work.

The base of the model attaches to a knife-edge strut which connects to a pitch actuating mechanism. The knife-edge strut that supports the model houses the pressure or temperature leads and is designed to minimize shock wave interference in the test flow area. The instrumentation leads are brought from the strut through the wall of the test cabin and out to the data recording instruments.

The models described in this article are but two of almost one hundred probes and models that have been designed and built in the ARL shops and under contract for use in the hypersonic test facilities. Without these models and their associated instrumentation, the ARL scientist

could not experimentally study the fundamental nature of hypervelocity gas behaviour in the wind tunnels.

Thus, it is of vital importance that ARL maintain and advance its competence in the field of model and instrumentation engineering. And it behooves the model and instrumentation engineer to devise new fabrication techniques to meet the instrumentation requirements that will be more difficult to achieve when experiments are conducted at higher Mach numbers because of higher temperatures and lower pressures.

THE USE OF PHOTOELECTRIC IMAGING DEVICES in ASTRONOMICAL SPECTROSCOPY

K. E. KISSELL,
GENERAL PHYSICS RESEARCH LABORATORY (ARL)

Absorption features in several dozen of the brightest stars were first noted in the 1860's, during the early days of stellar spectroscopy. This was done visually, with use of objective prism instruments, by L. M. Rutherford, Father Secchi and others. Since then, the similarities and differences of the spectra of individual stars have proved more and more to be the key to understanding the processes by which stars are born, live and evolve, and then subside either quietly or violently of old age.

During the decades following the introduction of photography into stellar spectroscopy by Henry Draper in 1872, the number of stars with recorded spectra rose above 400,000. However, not until the 1930's when suitable dye-sensitized emulsions were introduced by Eastman-Kodak, did stellar spectroscopy become possible in the near infrared. Throughout the history of stellar spectroscopy, the research undertaken has been limited or comprised by trade-offs of film speed, film resolution, and instrument dispersion (Angstroms per mm).

The classification of stars in terms of temperature-luminosity types can generally be handled by examination of relatively gross features such as hydrogen Balmer lines and blends of moderate strength lines such as molecular bands. This requires only low dispersion (100-500 A/mm), modest resolution and relatively short exposure times. On the other hand, the study of slow stellar rotation, photospheric turbulence or nuclear abundances requires high dispersion (1-4 A/mm) so that the

profiles of individual spectral lines can be obtained free from diffractive effects introduced by the spectrograph itself. Exposure times required by the 100" Hooker telescope run to 8 hours at 3 A/mm when one attempts to record spectra of stars at the limit of naked eye visibility.

The use of photographic plates revolutionized astrophysics, but photography still has many drawbacks. Photographic emulsions can record only 1 in 1,000 of the light quanta absorbed. Emulsions fail to follow the reciprocity law of exposure time. This sets a limit on the duration of exposure which is practical and also complicates the problem of sensitometric calibration of the emulsion, i.e., the inference of the true intensity of the source from the blackening obtained in the developed image. The spectral sensitometry of emulsions used today in spectroscopy can be established only to within $\pm$ 5%. These difficulties of emulsions make the use of photelectric detectors extremely attractive in stellar spectroscopy.

Photoelectric detectors are now available with spectral sensitivities extending well beyond the wave length limits of photographic plates and with peak quantum efficiencies of 30% in contrast to the 0.1% of photographic emulsion. Used in a scanning system at the focal plane of the spectrograph, over narrow wave length intervals ($\Delta \lambda$ = 10A), the photomultiplier spectrum scanner can compete [1] with emulsions in exposure time. However, over wider spectral intervals the parallel input of energy into all wave lengths of the plate soon penalizes the sequential scan necessary in the photoelectric device.

A desirable solution would appear to be the use of a photoelectric imaging device such as the image converter tube first developed in W W II or an integrating television camera tube such as the image orthicon. Since it is essential to utilize nearly all available photons, the phosphor output of a converter tube must be very efficiently coupled to the recording emulsion. In order to obtain exposure times equivalent to those of photographic systems, it is mandatory that the thermal electron emission of the photocathode be low in either device and that the storage target of the image orthicon be of sufficiently low conductivity to permit long integration times. Since 1954 the Committee on Image Tubes for Telescopes of the Carnegie Institution of Washington has been directing a program, now funded by NSF, aimed at development of new types of image tubes and has been conducting tests on these tubes at various observatories. At present several types of magnetically-focused tubes seem very promising.

In a recent tube tested by Dr. Kent Ford of the Carnegie Institution an S-20 photocathode permitted exposure times of 30 minutes at 14 kv accelerating potential without evidence of tube background. The particular tube, designed specifically for recording spectra, exhibited useful sensitivity out to 8000 Å although better photocathodes of this type are useful to 9000 Å. By using an S-1 response photocathode under cooled conditions it is possible to record spectra well beyond the limit of 1-Z photographic emulsion. Dr. Laurence Fredrick [2] of Lowell Observatory has utilized an early Image Tube Committee S-1 tube to record spectra to 13,000 Å. This enters the region where spectrum scanning with bolometers has been the only possible technique.

Another photoelectric imaging system offering good possibilities for long exposures is the image-orthicon equipped with an S-20 photocathode. J. H. DeWitt, Jr. of Dyer Observatory, under N.S.F. sponsorship, has devised a slow-readout camera system which has demonstrated stellar spectra exposure times of 10 minutes [3] and offers evidence of utility up to 60-minutes. DeWitt has reduced internal noise generation to a minimum by use of reduced scanning gun heater temperatures and internal light shields in the image orthicon. This system offers hope of non-photographic readout of the information by use of radio-frequency tape recording and thus admits the possibility of computer processing of the spectral record, scan line by scan line.

It then appears that IR sensitive photoelectric imagining devices may permit work in the near infra-red where photographic emulsions have been at a disadvantage. What type of astrophysical problems would be attacked if a speed gain of 10 could be achieved? The struggle for perfection of a new instrument must hold promise of significant rewards. In the case of near IR spectroscopy at moderate resolution, several problems suggest themselves, since the inconveniently long exposure times have limited prior work to the bright stars.

In a follow up of a pioneering survey by Merrill [4] at Mt. Wilson, Hynek and Keenan [5] of Perkins Observatory studied the effects of luminosity on the high excitation neutral oxygen triplet lines at λ 7774 and λ 8446. This study confirmed Merrill's suggestion of the utility of the λ 7774 lines as a sensitive indicator of high luminosity and established it as the most sensitive of all luminosity criteria yet found. The unfortunate location of these lines in the photographic I.R. has precluded its use in spectral classification, however, and required Hynek

& Kennan's calibration of the lines as a luminosity indicator to be somewhat spotty at the high luminosities because of lack of suitable stars of sufficient brightness. Only fifty some stars were included in the survey. Only five supergiant stars in luminosity class Ia and twelve of class Ib had recordable lines. It was established that only the total absorption of the blend of lines was necessary for use of these lines as a luminosity criteria.

With the advent of infra red sensitive photoelectric imaging devices, it may now be practical to exploit the OI lines in fainter stars. The lower resolution of the image tube or image orthicon can be accepted as long as the total absorption of the blended lines is still measurable. An interesting possibility is the study of the behavior of these lines in high luminosity variable stars such as RR Lyrae or some of the classical Cephieds. From the work of Hynek and Keenan it could be expected that RR Lyrae will show considerable variation of total absorption in the λ 7774 blend if the exposure time can be reduced to time intervals short compared to its 0.5668 day period. Similarly the Cepheid variables may show changes in the OI blend and other near IR features. The calibration of supergiants, particularly those of the brightest class, should be improved by enlarging the observational basis.

Slettebak [6] of Perkins Observatory examined the neutral oxygen lines in two classes of peculiar stars, the Be stars where anomalous emission characteristics had been noticed by Merrill and Hynek and Keenan, and in the peculiar A stars where Hynek and Keenan had noticed that the OI lines were sometimes either weak or missing. It is not without hope that an extension of the spectral catalogue to fainter stars will disclose new clues to these anomalous characteristics or show still more peculiar properties.

Another application certainly to be explored is the measurement of the continuum radiation from the star. This is important in establishing the effective temperature of the star. This problem has most recently been attacked by Oke [7] of Mt. Wilson using a spectrum scanner on the 100" telescope at Mt. Wilson. Computation shows that the image orthicon should permit establishment of the continuum with the same spectral resolution and quantum fluctuations in only 60 seconds compared with Okes scanning time of 30 minutes.

It is thus natural that, as a follow-on to some of the early work in high-sensitivity image orthicons by R.H.K. Gebel at ARL, a version of the Dyer Observatory slow-scan image orthicon camera

system is being built for use in spectroscopy of faint sources. It is planned to test this camera system on the Perkins 69" telescope now located at Anderson Mesa, Arizona, as part of the Lowell Observatory complex. The Perkins instrument is equipped with a grating spectrograph which is of high efficiency in the 7000-8000 Å region at dispersions highly suited for work with the neutral oxygen lines. Through use of a spectrum only a few scan lines in width and by using a form of multi-channel analyzer capable of recording the resolution elements of the spectra in the individual scans, it is expected to achieve the required factor of 10 in exposure time, and hoped to reach a factor of 25. In the interim, the author is participating both in the testing of mica-window cascaded image tubes of both the S-20 and S-1 type, these tests being conducted by the Carnegie Institution of Washington and Lowell Observatory and in the tests of the Dyer Observatory slow-scan image-orthicon also being conducted at Lowell Observatory. Preliminary results obtained with an S-20 mica window tube sing the Morgan 24" telescope at Lowell Observatory showed a speed gain of only 3 with a photocathode of average white light sensitivity and below normal infra red sensitivity. This confirms that an S-20 sensing tube must be selected for an infra red tail whether it is of image tube or image orthicon type. It is reported that an oxidized tri-alkali (modified S-20) photocathode has been successfully prepared by Lallemand of the Observatoire de Paris-Meudon. This photocathode is said to have its peak sensitivity at λ 6800 rather than λ 4200 and should offer substantial improvements in the near IR if and when it can be incorporated into photoelectric imaging devices.

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